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Research Article

Portable Smart Emergency System Using Internet of Things (IOT)

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ABSTRACT

The portable smart emergency system is a pre-test tool, implemented using a set of modern devices and technologies to monitor the patient's health. This tool has capability to send reports of the patient to the doctor treating the patient as well as to the relatives, close friends of the patient in real time. Health parameters of the patient viz. heart rate, blood oxygen and temperature are monitored using electronic devices viz. WEMOS D1, MAX30100, DS18B20, SIM808 on the LCD screen and stored using the MySQL database. PHP script is used to connect MySQ database for easy tracking and analysis of medical data. Doctors are facilitated to monitor the health update in real time, at the same time, communicate the same to the patient and their relatives, close friends through a dynamic web site constituted of HTML, CSS and JavaScript for the purpose of easy tracking and analysis of the medical data. To aid further, as a part of value addition, an Android based mobile app is also developed by using App Inventor to further facilitate patients, family members & close friends to monitor sensor data, receive messages and access medical history details, all in real time. Terminal cases, where the health update received from the sensor shows alarmingly high or low readings, then web enabled computing system, also sends a high alert message by playing a warning sound to the doctor, at the same time, also communicates patient's location to him via text message to enable immediate help. By using Wi-Fi technology and the SIM808 module, the patient's location can be monitored in emergency situations and a text message containing the patient's geographical location can be sent to the treating doctor. This application also includes an option to enter the patient's medical history information using a PHP script into the database.

1. INTRODUCTION

The study's proposed patient monitor and emergency system would track the patient's vitals in real time and allow the doctor and patient to communicate from afar. The system makes use of a number of sensors [1-3], such as the MAX30100 sensor for monitoring heart rate and SpO2 and the DS18B20 sensor for measuring temperature. As well as a web app enabling doctors to see vital signs, there's also an Android app for patients or their close relatives and friends to use for remote health monitoring. Additionally, the system's built-in alert systems will notify the doctor if the patient's vital signs suddenly and drastically change from the normal ranges. Research into patient monitoring and emergency response systems seeks to improve healthcare by creating an all-encompassing system that uses a wide range of sensors and forms of electronic communication to solve common difficulties experienced by both patients and medical professionals. The research is motivated by a desire to enhance healthcare delivery by expediting emergency response times and encouraging individual patient agency.

2. METHODOLOGY

The current healthcare system lacks a reliable and efficient way to monitor patients remotely, which can lead to delayed medical intervention in case of emergencies. Additionally, patients often struggle to keep track of their medical information and communicate with their doctors effectively. The present proposal helps to address the problems in a more holistic manner. The proposed study is divided into two integral parts: hardware environment and software tools and techniques.

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2.1 Hardware environment

The hardware environment plays a crucial role in the implementation of proposed smart healthcare monitoring system. The hardware environment constituting sensors used in this research are responsible for acquiring the physiological data of the patient and comprehensively communicates to the software for analysis and interpretation. The hardware environment includes the following parts:

2.1.1 WeMos D1

The WeMos D1 board in this study is used to collect parameters like heart rate, SpO2 value, and temperature readings from the patient using MAX30100 and DS18B20 sensors. It enables WiFi connectivity and GSM communication with the SIM808 module to send the collected data to a MySQL database via PHP scripts. The board also displays real-time sensor data on an LCD screen and integrates the Android app and website for remote monitoring by the doctor. Overall, the WeMos D1 plays a critical role in seamless communication between the various system components and real-time monitoring of the patient's vital signs [1].

2.1.2 SIM808

In this hardware setup, the SIM808 module plays a pivotal role. It has three primary features: GSM phone functionality, GPS location tracking, and Bluetooth wireless technology. If the patient's vital signs drop too low or rise too high, the GSM function will transmit an alert to the doctor. In the event of an emergency, the SIM808 module can also be used to send the doctor's cell number the patient's location through GPS. In an emergency, knowing exactly where a patient is at all times is crucial; the SIM808's GPS functionality makes this possible. With this function, the doctor may quickly identify where the patient is. In addition, the SIM808 module's Bluetooth capabilities are utilised to link the Android app to the WeMOS D1 board. The ESP8266 can be connected to through Bluetooth and Wi-Fi with the software [4].

2.1.3 MAX30100

The MAX30100 sensor is used to monitor the patient's pulse and blood oxygen saturation (SpO2) levels. This sensor has a high-performance analogue front-end coupled with an LED and a photo sensor for precise measurements. The MAX30100 sensor is a vital part of the patient monitoring system, and its compact dimensions (5.6 mm x 2.8 mm x 1.2 mm) make it ideal for use in wearable devices. With features like excellent SNR (Signal-to-Noise Ratio) and powerful motion artefact robustness and ambient light rejection, the MAX30100 sensor guarantees precise measurements in any setting. Fast and precise data gathering is essential in a real-time monitoring system, and the sensor's high sample rate capability makes that possible [2].

2.1.4 DS18B20

When researching patient monitoring and emergency systems, the DS18B20 sensor is crucial. It allows the patient's temperature to be taken, which is a very important indicator of their health. The DS18B20 sensor's temperature measurements, accurate to within 0.5 degrees Celsius from -10 degrees Celsius to 85 degrees Celsius, can be transmitted to a database through a PHP script. This data is essential for the doctor and family members to keep track of the patient's health and intervene if necessary [3].

2.1.5 LCD

The gadget has an LCD screen that displays the patient's vital signs (heart rate, SpO2 value, temperature, etc.) as they are measured by the sensors in real time. The health of the patient can be simply monitored by the doctor or a family member. It can also show alerts and warnings when sensors detect something out of the ordinary or an emergency occurs.

2.1.6 Lithium Battery, BMS, Battery Indicator

The purpose of the lithium battery in the device is to provide a reliable and long-lasting power source for the system. The battery management system (BMS) is responsible for monitoring the battery's voltage, temperature, and current, and protecting it from overcharging, over-discharging, and overheating. The battery indicator is used to display the battery level, ensuring that the user is aware of the remaining battery capacity.

2.1.7 *SPST Switch, Push Button Switch*

SPST switch is used to judiciously operate the battery in turn ON / turn OFF condition, so as to keep the battery life to the optimum. Two push button switches are used in the project: first one to reset the device, and the second one for checking battery indicator.

2.1.8 DC Power Jack, Two Micro-USB Connector

DC power jack is used for charging the device with 9 V power adapter. Two micro-USB connectors are used: one for connection to MAX30100 device and the other for connection to DS18B20 device.

2.1.9 Plastic Box, Finger Probe

The plastic box is used to contain all device components together to give a professional look to the device. The finger probe is used to contain the MAX30100 sensor, so that the patient can easily put his finger on the pulse oximeter.

2.2 Software Technologies

The patient monitor and emergency system is a software-based system that uses various technologies as shown in Table 1, to collect, process, and display patient data in real time [5-10].

TABLE I. SOFTWARE TECHNOLOGIES.

Software	Description
Arduino IDE	Used to program the WEMOS D1 microcontroller to read sensor data and communicate with external systems
PHP script	Used to create server-side scripts to receive and send data from and to the microcontroller, store it in a MySQL database, and display it in real-time on a website
HTML, CSS, and JavaScript	Used to create the web application that displays the patient data in real-time and allows doctors to send messages to the patient or their relatives
App Inventor	Used to create the mobile application that displays the patient data and receives messages from doctors.
MySQL	Used to store the patient data in a database
Tinker cad	Used to design 3d plastic box and finger probe

2.3 System Design

The central component of the proposed project, patient monitoring system, is WeMOS D1 microcontroller. It serves as the main control unit. Vital signs are measured by interfacing temperature, heart rate pulses, and SPO2 sensors with the microcontroller. The LCD display is connected to the microcontroller to provide real-time visual feedback of the patient's vital signs. Additionally, GSM technology is utilized to send critical alerts to the mobile phone of the doctor, and GPS technology is employed to track the patient's location. The use of lithium batteries and a battery management system (BMS) makes the device portable. All components are integrated and connected as shown in the diagram.

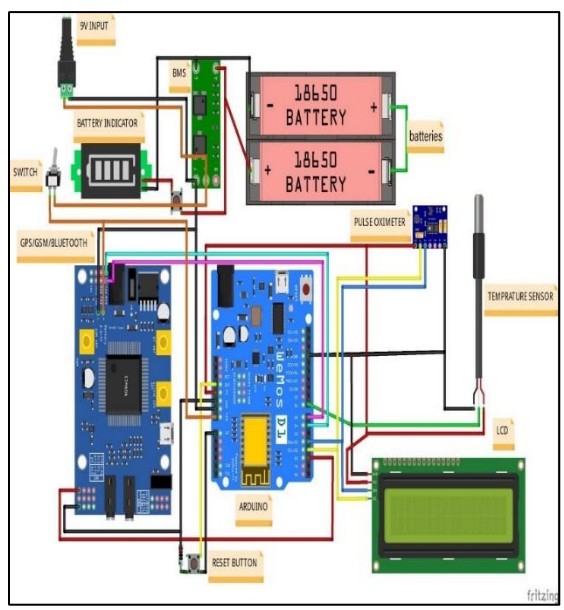

Fig 1. System design

2.4 System Implementation

Figure 2 illustrates the implementation stages of the proposed system where the first step of the system is for the user (the patient or a relative) to input the patient's medical history through the mobile app[10]. Additionally, the app allows for the input of the WIFI network name and password so that the device can connect to the internet. Once connected, the device initializes the GPS location and begins sending sensor readings to the MySQL database in real time. In the event of abnormal readings, the device sends an SMS to the doctor's mobile phone and the ambulance driver via GSM, and the web app activates an alarm to alert the doctor to make him aware about the critical situation. The doctor can respond by sending a message back to the Android app, allowing the patient's relatives to follow the doctor's instructions.

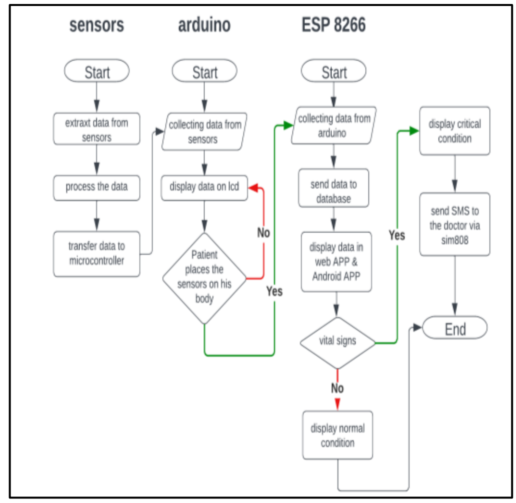

Fig. 2. System implementation flowchart

Whereas, Figure 3 outlines the various elements used in the system, such as the WEMOS D1, MAX30100 sensor, DS18B20 sensor, SIM808 module, LCD screen, and Wi-Fi connectivity. These components work together to collect vital signs from the patient and send them to the database via a PHP script, allowing doctors to monitor patient health in real-time via the website. The study also includes an Android app developed using App Inventor that patients or their relatives can use to monitor sensor readings and receive messages from the doctor. Additionally, it also includes a warning system that triggers an alarm and sends an SMS to the doctor and ambulance driver when abnormal readings are detected, allowing for timely action to be taken in emergency circumstances.

The realistic shape of the device is shown below in Figure 4:

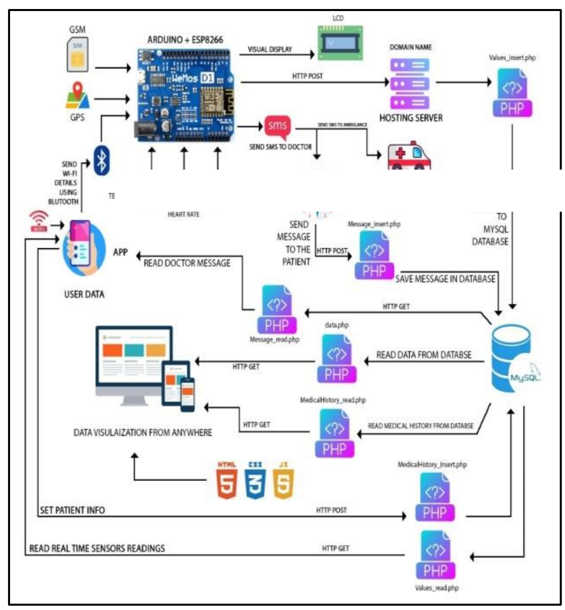

Fig. 3. System implementation in detail.

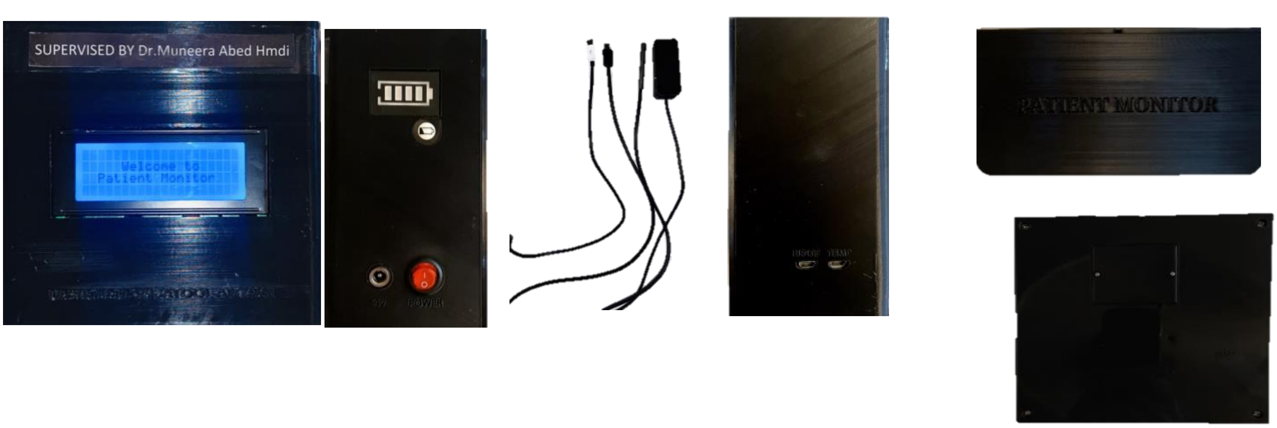

Fig. 4. The realistic shape of the device.

3. DATA COLLECTION AND ANALYSIS

The data in our system is obtained after examining the patient's condition using the device of patient monitor and entering its medical info, after which this sensor readings and patient information and the messages sent by doctor are stored using MySQL which is an open-source relational database management system (RDBMS) that is widely used for web applications and other types of software. It is one of the most popular databases in the world and is known for its reliability, scalability, and ease of use it is written in C and C++ and supports a wide range of operating systems, including Windows, Linux, and macOS. MySQL is also highly customizable, with a large number of plugins and extensions available to add additional functionality [5]. In this study, we have three sub-databases in our fully database system, one for displaying the doctor messages which is sent by doctor to the patient from the web to the app. And another one for showing the medical history of the patient that we entered using the android app and it also display in the web in the patient info section. And the last sub-database is for the patient data that is representing the sensor readings for the patient that is measured using the device. The PHP script is used to communicate with the database and perform various operations such as retrieving data, inserting new data, and updating existing data [6]. All the data is stored and the doctor can display it in the web from the first reading of the patient until the last one by determine the number of readings he want to display or by click on the maximize button to show the whole readings.

4. RESULTS AND DISCUSSION

During the testing phase, the WeMOS D1 microcontroller was found to be highly reliable and efficient in performing its tasks. It successfully interfaced with the Max30100 sensor and DS18B20 sensor, and accurately read the heart rate, SPO2, and temperature of the patient. Further, we analyze the level of accuracy of our experiments by comparing our generated data from MAX30100 to the medical-approved HR and SpO2 measurement device. The test was done on 8 patients' males and females of different ages. Moreover, in order to compare the accuracy of our MAX30100 sensor with a medically approved oximeter, we conducted a continuous 5-minute test on a single patient and recorded the readings from both sensors. Afterwards, we used Python to graphically represent and analyze the data to highlight any differences between the two sensors. The results of this test allowed us to evaluate the precision of the MAX30100 and determine its reliability in detecting the patient's vital signs. The results showed that the readings obtained from the MAX30100 sensor were highly accurate and closely matched with the medically approved oximeter. This indicates that the MAX30100 sensor can be used effectively in monitoring the patient's vital signs in real time [11].

To examine the accuracy and error rate of the used sensors we estimated the following equations:

$$Error = \frac{\text{Average(commercial device readings} - \text{MAX30100 readings)}}{\text{commercial device readings}} \times 100\% \qquad (1)$$

Average (commercial device readings – Max30100 readings): It is the average value of commercial device readings relative to MAX30100 device readings. While, commercial device readings: Commercially approved device readings.

$$Accuracy = 100\% - Error \qquad (2)$$

Where, error: it is the possible error in measurement.

Accuracy: The accuracy of the device readings after the experiment.

As we discussed above, we analysed the sensor output data for accuracy and error rate using equations (1) and (2), and found that the SPO2 data had a relatively low error value of 1.90% and an accuracy of 98.1%. The heart rate data calibration likewise produces excellent results, with an error value of 0.15% and an accuracy of 99.85%. In our investigation, we employed a DS18B20 temperature sensor to track the subject's core body temperature. In the study's validation phase, we compared the sensor's readings from eight patients to those from a standard medical thermometer to determine its level of accuracy. We logged and analysed data from both sensors. We discovered that the DS18B20 sensor was precise enough for our needs, and the findings were quite close. The measurements from the sensor were found to be highly consistent with those from the thermometer, with a maximum error of 0.27 percent and an accuracy of 99.73 percent, respectively. We found that the DS18B20 sensor was suitable for monitoring the patient's body temperature because it met the accuracy standards of our study. However, we must remember the sensor's shortcomings and be diligent about keeping it calibrated to ensure continued precision. Our study also included a thorough evaluation of the functioning of the SIM808 module, which was employed for both GPS position tracking and GSM communication. The AT instructions allowed us to monitor the module's signal strength, pinpoint its location through GPS, and send text messages. Because it enabled real-time GPS tracking of the patient's location and provided dependable communication channels in case of crises, the SIM808 module was crucial to our study. We had to be careful not to use up the SIM card's credit by sending too many SMS messages. As an added precaution against system breakdowns due to low voltage, we made sure the module had its own dedicated power supply.

5. CONCLUSION AND FUTURE WORK

The study's primary objective was to devise and implement a patient monitoring system capable of real-time vital sign tracking and two-way communication with medical staff. The MAX30100 pulse oximeter, DS18B20 temperature sensor, SIM808 module, and WeMOS D1 microcontroller were some of the hardware components merged with software technologies including Wi-Fi, GSM, and GPS to form the system. Through trial and error, we were able to ascertain the precision and scope of each hardware component and software technology. The work was successful in developing a patient monitoring system capable of real-time vital sign tracking and two-way communication with medical personnel. The system's promise to improve patient outcomes rests in its ability to facilitate remote patient monitoring and facilitate rapid medical response in the event of an emergency. The study's contributions to patient monitoring include a blueprint for future patient monitoring systems and the identification of the strengths and limits of various hardware components and software technologies. Adding a blood pressure sensor to the system so that it can analyse pulse and blood pressure values is just one example of the many potential future challenges and improvements discussed in the paper. As well as enhancing the functionality of Bluetooth in the SIM808, where problems like connection delays might lead to malfunction. Deep learning and data extraction from two PPG sensors were used to create a cuff-less pressure sensor, however this approach was too time-consuming and outside the scope of our study to be practical. Making the system accessible to more than one patient would require creating a database for every patient who is using the device, as well as improving the accuracy of sensor readings, optimising the system's communication technologies, and developing a user-friendly interface for healthcare providers and patients.

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Conflicts of Interest

The author declares no conflict of interest in relation to the research presented in the paper.

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